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PATENT SPECIFICATION

NO DRAWINGS

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COMPLETE SPECIFICATION

Improvements in or relating to the production of Composite Metal Sheets

We, E.I. Du Pont De Nemours & Company, a Corporation organized and existing under the laws of the State of Delaware, United States of America, of Wilmington 98, Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention concerns improvements in or relating to the production of composite metal sheets, and is an improvement in or modification of the invention described in our prior Patent Specification No. 923,746.

At present, metals are generally bonded (clad) by placing a sheet of one metal between two pieces of the same or different metals and then hot rolling the combination. This process has many disadvantages, which, we believe, principally result from the high temperatures necessary to carry out the hot rolling operation. For example, many metals melt or are otherwise sensitive to the temperatures used, or absorb undesirable materials or form undesirable intermetallic phases at these temperatures. Furthermore, metals have different degrees of rollability, and different thermal expansions. Not all of these disadvantages can be overcome by operating in an inert atmosphere, and such operation is expensive even when it does work. Electrowelding and brazing are presently less preferred generally as methods of making clads, and are subject also to many of the disadvantages indicated above. Furthermore, heretofore it has not been possible to make satisfactory titanium steel and tatalum steel clad pieces by any prior art method, on account of intermetallic compound formation and absorption of atmospheric embrittling agents, and no "Hastelloy (Registered Trade Mark) C" clad pieces with satisfactory corrosion resistance have yet been made available because of carbide precipitation.

In our prior Patent Specification No. 923,746, we have described and claimed a process for bonding together metallic layers to form a multilayer body, which comprises supporting one or more metal cladding layers separated from a metal base layer or an adjacent cladding layer by a distance of at least 0.001 inch and in substantially parallel relationship thereto, placing a layer of a detonating explosive on the outside surface of the outermost cladding layer, said explosive having a detonation velocity less than 120% of the velocity of sound in the metal in the system which has the highest sonic velocity, and initiating the said explosive in such a way that the detonation is propagated in a direction parallel to the said metallic layers. The present invention provides a process for obtaining thin clad metal sheets which comprises forming a composite metal sheet from at least two metals by the said bonding process claimed in our Patent Specification No. 923,746 and cold rolling the composite thus formed to reduce its thickness.

The cold rolling may be performed by conventional equipment, e.g. tandem mills or reversing mills, tandem mills being preferred from the standpoint of high output. Sandwich rolling can also be performed where two sheets, for example each being combinations of clad metals, can be rolled simultaneously.

It may be possible to obtain a predetermined thickness desired in a single rolling operation. The maximum reduction in thickness which can be accomplished in one rolling operation depends on the metals concerned, but is in general about 20 to about 90% of the original thickness. The following table, for example, shows typical ranges for various combinations:

Metal Combination		% reduction from original thickness
Cladding Metal	backer	
titanium	steel	20 - 40
tantalum	steel	50 - 95
gold	nickel	50 - 90
copper	steel	50 - 90
stainless steel	aluminium	30 - 60
stainless steel	steel	40 - 90
nickel	steel	50 - 95
"Monel" (Registered Trade Mark)	steel	50 - 90
stainless steel	copper	30 - 70

Most metals, such as stainless steel, work harden to a significant extent during cold rolling. This hardness is generally removed by a conventional annealing operation, for example if a further cold rolling operation is required to further reduce the thickness. The time and temperature of annealing will depend on the particular metals involved.

If necessary, a conventional descaling treatment should be used to remove and scale formed, e.g. during the annealing, and this treatment should be appropriate to the particular metals involved. For example, sodium hydride descaling is suitable for carbon steel, stainless steel, nickel, "Monel," "Inconel" (Registered Trade Mark), copper, "Nichrome" (Registered Trade Mark), high chrome steels, cobalt-nickel steel, brass, bronze and gold, but not for tantalum or aluminium. Aqueous sulphuric acid is a suitable descaling agent for steels and tantalum. Aqueous nitric acid is a suitable descaling agent for aluminium and stainless steel. The details, such as temperature, time and acid strength will depend on the particular metals used. If the metal is highly resistant to oxidation, abrasive action, for instance, by a polishing wheel, may be sufficient for descaling. If the annealing is performed in a vacuum or in an inert atmosphere, no descaling may be necessary. It will generally be desired that no one of the metals be excessively attacked. If necessary, each side of a composite can be descaled separately by different agents, one side being protected while the other is being descaled.

Satisfactory clad metals according to the present invention have been made from the following systems, among others; copper and its alloy such as brass, bronze and "Monel" on Steel; nickel and its alloys such as "Monel," "Inconel," "Invar" (Registered Trade Mark), the "Hastelloys," nickel-silver and "Nichrome" on steel; chromium and its alloy on steel; titanium and its alloy on steel; the noble metals (e.g. gold, platinum, silver, palladium, iridium and rhodium) and their alloys on steel, nickel and other metals; tantalum and its alloys on steel; zirconium and its alloys on steel. Other combinations can be used but, in general, there is little interest at present in putting metals onto backers other than steel and its alloys except that the noble metals are clad onto stainless materials such as nickel for jewellery.

The following Examples are given to further illustrate the invention; all parts and percentages are by weight.

Example 1

A layer of titanium 0.0508 cm thick is clad explosively by the method described in Specification No. 923,746 to a layer of 1008 killed steel 0.477 cm. thick. The combination is passed through a cold rolling mill and cold rolled to a total thickness of 0.3556 cm. The sheet is then annealed for 20 minutes at 700°C. and descaled in a molten sodium hydroxide bath at 700°C. containing 2% sodium hydride for 1 hour.

The combination is again passed through the rolls and cold rolled to 0.254 cm, the predetermined thickness desired, annealed and descaled as above.

The final sheet has excellent corrosion resistance. Exposure of the titanium side by immersing in 5% sodium chloride solution for 5 days shows no evidence of corrosion.

The sheet can be bent through 90° around a mandrel having a radius of 0.508 cm without cracking or layer separation.

Further reduction in thickness to about 0.1787 cm is attained by passing again

through the rolls, followed by annealing and descaling. The sheet can be bent through 90° over a mandrel having a radius of 0.1778 cm without layer separation.

EXAMPLE 2

A layer of tantalum of 0.0762 cm thick is explosively clad by the method described in Specification No. 923,746 to a layer of mild steel 0.635 cm thick. This combination is passed through a rolling mill and cold rolled to 0.3556 cm, the predetermined thickness desired. The combination is then annealed at 110°C. in a vacuum furnace. No descaling treatment is necessary because of the vacuum annealing.

A sample of the combination can be bent through 90° over a mandrel of radius 0.3556 cm without layer separation or cracking occurring.

" Monel " is similarly clad to steel and the composite is rolled with similar results.

EXAMPLE 3

A layer of gold 0.159 cm thick is explosively clad by the method described in Specification No. 923,746 to a layer of nickel 1.27 cm thick. This combination is passed through a rolling mill and reduced in thickness to 0.3048 cm, the predetermined thickness desired. The combination is then annealed at 700°C. for 20 minutes. No descaling is needed except a mild abrasive action. If the annealing is done in an argon atmosphere the abrasive action is not needed.

The combination can be further reduced in thickness to 0.0635 cm by a second passage through the rolls followed by a similar annealing treatment.

The combination is cut with a saw, and the interface is analysed chemically to show that the gold has not diffused into the nickel to any significant extent.

Silver on steel is prepared and rolled similarly with equivalent results.

EXAMPLE 4

A layer of type 304 stainless steel 0.0254 cm thick is explosively clad by the method described in Specification No. 923,746 to a layer of 0.1905 cm thick of " Alcoa (Registered Trade Mark) 7075 " aluminium alloy, containing 5.5% zinc, 2.5% magnesium, 1.5% copper and 0.3% chromium. This combination is cold rolled to give a sheet 0.1294 cm thick. The sheet is useful for architectural panels without annealing, but can be annealed at 600°C. for 15 minutes to give a more flexible sheet.

EXAMPLE 5

An explosively clad sheet is made exactly as described in Example 1, except that a titanium layer 0.0508 cm thick is clad on each side of the killed steel, and the cold rolling operations reduce the thickness of the clad sheet first to 0.381 cm and then to 0.2794 cm. This sheet can also be bent around a mandrel 0.508 cm in radius without cracking or separation of layers.

EXAMPLE 6

A sheet of type 304L stainless steel 0.0635 cm thick is explosively clad by the method described in Specification No. 923,746 to a sheet of low carbon steel 0.635 cm thick. The composite is cold rolled to 0.254 cm, annealed at 1650°F. for 5 minutes, descaled in a molten sodium hydroxide bath containing 2% sodium hydride at 700°F., cold rolled again to 0.1116 cm, the predetermined thickness desired, and annealed and descaled again under the same conditions as before.

The finished sheet can be bent over a mandrel 0.2032 cm in diameter without cracking or separation of the layers. On exposure to a salt spray for 100 hours no pitting of the stainless steel side of the clad is noted.

The alloys " Monel," " Inconel," " Invar," " Nichrome " and the " Hastelloys " have the compositions given in A. D. Merriman " A Dictionary of Metallurgy," MacDonald and Evans (1958). The compositions of 1008 killed steel and 304 stainless steel are given in " Metals Properties," ASME Handbook, McGraw-Hill (1954). Type 304L stainless steel has the same composition as type 304 except that the carbon content is 0.03% maximum.

WHAT WE CLAIM IS :

1. A process for obtaining thin clad metal sheets which comprises forming a composite sheet from at least two metals by a bonding process claimed in our Patent Specification No. 923,746 and cold rolling the composite thus formed to reduce its thickness.

2. A process according to claim 1, wherein the thin clad metal sheet is annealed.

3. A process according to claim 2, wherein the annealing is performed in a vacuum or in the presence of an inert gas.

4. A process according to claim 2 or 3, wherein the annealed sheet is descaled.

5. A process according to any of the preceding claims, wherein the composite sheet is subjected to more than one cold rolling operation.

6. A process according to any of claims 1 to 5, wherein a thin titanium sheet is bonded to a thicker steel sheet.

7. A process according to any of claims 1 to 5, wherein a thin tantalum sheet is bonded to a thicker steel sheet.

8. A process according to any of claims 1 to 5, wherein a thin gold sheet is bonded to a thicker nickel sheet.

9. A process according to any of claims 1 to 5, wherein a thin copper sheet is bonded

to a thicker steel sheet.

10. A process according to any of claims 1 to 5, wherein a thin stainless steel sheet is bonded to a thicker aluminium sheet.

11. A process according to any of claims 1 to 5, wherein a thin stainless steel sheet is bonded to a thicker steel sheet.

12. A process according to any of claims 1 to 5, wherein a thin nickel sheet is bonded to a thicker steel sheet.

13. A process according to any of claims 1 to 5, wherein a thin "Monel" sheet is bonded to a thicker steel sheet.

14. A process according to any of claims 1 to 5, wherein a thin stainless steel sheet is bonded to a thicker copper sheet.

15. A process according to any of claims 1 to 5, wherein a thin copper-containing alloy sheet is bonded to a thicker steel sheet.

16. A process according to claim 15, wherein the copper-containing alloy is a brass or bronze.

17. A process according to any of claims 1 to 5, wherein a thin nickel-containing alloy sheet is bonded to a thicker steel sheet.

18. A process according to claim 17, wherein the nickel-containing alloy is a "Monel," "Inconel," "Invar," "Hastelloy" or "Nichrome" alloy (as hereinbefore defined) or nickel silver.

19. A process according to any of claims 1 to 5, wherein a thin chromium-containing alloy sheet is bonded to a thicker steel sheet.

20. A process according to any of claims 1 to 5, wherein a thin gold sheet is bonded to a thicker steel sheet.

21. A process according to any of claims 1 to 5, wherein a thin platinum sheet is bonded to a thicker steel sheet.

22. A process according to any of claims 1 to 5, wherein a thin silver sheet is bonded to a thicker steel sheet.

23. A process according to any of claims 1 to 5, wherein a thin palladium sheet is bonded to a thicker steel sheet.

24. A process according to any of claims 1 to 5, wherein a thin iridium sheet is bonded to a thicker steel sheet.

25. A process according to any of claims 1 to 5, wherein a thin rhodium sheet is bonded to a thicker steel sheet.

26. A process according to any of claims 1 to 5, wherein a thin platinum sheet is bonded to a thicker nickel sheet.

27. A process according to any of claims 1 to 5, wherein a thin silver sheet is bonded to a thicker nickel sheet.

28. A process according to any of claims 1 to 5, wherein a thin palladium sheet is bonded to a thicker nickel sheet.

29. A process according to any of claims 1 to 5, wherein a thin indium sheet is bonded to a thicker nickel sheet.

30. A process according to any of claims 1 to 5, wherein a thin rhodium sheet is bonded to a thicker nickel sheet.

31. A process according to any of claims 1 to 5, wherein a thin zirconium sheet is bonded to a thicker steel sheet.

32. A process according to any of claims 1 to 5, wherein a thin zirconium-containing alloy sheet is bonded to a thicker steel sheet.

33. A process according to any of claims 1 to 5, wherein a thin tantalum-containing alloy sheet is bonded to a thicker steel sheet.

34. A process according to claim 1 substantially as hereinbefore described.

35. A process according to claim 1 substantially as described in any of the foregoing Examples.

36. A thin bonded metal sheet prepared according to the process of any of claims 1 to 35.

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